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GROWTH RATE OF THE ENDOPHYTIC SYSTEM OF THE DWARFMISTLETOE ON DIGGER PINE[1]

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ABSTRACT

The endophytic system of dwarfmistletoe in Digger pine was closely associated with branch swelling. Growth rate of the system was directly related to host vigor. Season of the year and age of infection had no effect. Suggestions for control by pruning are included.

Little is known about the growth rate of the endophytic system of the dwarfmistletoe Arceuthobium campylopodum Engelm. Shea[3] found a highly significant correlation between the extent of swelling of branches of ponderosa pine (Pinus ponderosa Laws.) and the extent of the corresponding endophytic system of A. campylopodum. Also, an increase in branch diameter was associated with an increase in the proximal extent of the endophytic system and the associated swelling. Branch height and distance of the swelling from the bole showed no consistent relation to the extent of either the endophytic system or the length of swelling. Hawksworth[4] reports that for both A.

1/ Part of the work reported here was based on a thesis submitted by the author to the Graduate Division of the University of California in partial fulfillment of the master's degree.

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3/ Shea, K. R. Extent of the endophytic system of dwarfmistletoe on ponderosa pine. Phytopath. 47(9):534 (Abstr.). 1957.

4/ Hawksworth, Frank G. Growth rate of dwarfmistletoe infections in relation to crown class of the host. U.S. Forest Serv. Rocky Mtn. Forest and Range Expt. Sta., Res. Note 41. 1960.

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americanum Nutt. ex Engelm. on lodgepole pine (Pinus contorta Dougl.) and A. vaginatum (Willd.) Presl. on ponderosa pine the growth rate of infections in the boles of dominant trees was nearly twice that in suppressed trees.

The study reported in this paper deals with A. campylopodum on Digger pine, Pinus sabiniana Dougl., in Mt. Diablo State Park in the coastal mountains of west central California. Naturally infected trees occur in open stands at elevations between 1,500 and 4,000 feet. Temperatures are favorable for tree growth during most of the year, but moisture may be a limiting factor in growth for a considerable period in the late summer.

The purpose of the study was to obtain information on (1) the extent of the endophytic system beyond the limits of swelling and (2) the rate of extension of the endophytic system as influenced by host vigor, season of the year, and age of infection. Such information helps understand the development of individual dwarfmistletoe infections and has application in the formulation of guidelines for its mechanical eradication.

METHODS

Branch infections selected at random on several vigorous trees were used to study the growth rate of the dwarfmistletoe. Bole or multiple branch infections were not used. The initial extent of infection as judged by the limits of swelling was marked by driving small wire brads into the branch at the margin of the swelling. Subsequent distal and proximal extension of swelling was measured to 0.1 inch from these initial points. Measurements were taken at 6-month intervals. The months from April through September were arbitrarily chosen as comprising the summer growing period, and October through March as the winter period. Vigor of the host branches was estimated in April 1961 at the time of the last growth measurement.

To determine if the endophytic system extended beyond the area of swelling, 20 branch infections were taken into the laboratory for examination. Transverse discs approximately 1/4-inch thick were cut from the branch at 1-inch intervals along the swelling and also at points 1 inch beyond the limits of swelling. These discs were imbedded in paraffin and sectioned transversely on a rotary microtome at 15 microns. The sections were stained with safranin and fast green, mounted on glass slides, and observed with a compound microscope for the presence of the endophytic system of the parasite.

Ages of the infections used for growth measurements were determined in the laboratory after all measurements had been made. Additional infections were also collected for age determinations. Transverse discs approximately 1/4-inch thick were taken from the host branches at the apparent point of infection near the midpoint of the swelling, smoothed on a sliding microtome, stained with phloroglucinol in 18 percent hydrochloric acid, and examined under the low power of a dissection microscope. The number of annual rings showing a growth stimulus or the presence of sinkers of the parasite was considered the approximate age of infection. One year was then added to allow for germination, penetration, and establishment of the parasite.

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RESULTS

Microscopic examination of sections from infected branches showed the endophytic system of the parasite consistently associated with swollen host tissue. The endophytic system was not observed in host tissue at a distance of an inch beyond the swelling, however.

The extension of the endophytic system varied among infections. The number of infections by growth classes, as indicated by extension of swelling in 2 years, was:

Extension of swelling in inches (April 1959 - April 1961)	Number of infections
0 - 1	0
1 - 2	2
2 - 3	6
3 - 4	18
4 - 5	8
Over - 5	1

The growth of these infections ranged from 1.3 inches for the slowest to 5.1 inches for the fastest growing infection.

Vigor of the host branch affected the growth rate of the parasite. The growth of 22 infections on vigorous host branches averaged 3.6 in 2 years; that of 11 infections on branches of poor vigor averaged 2.9 inches.

The average growth rate of all infections is given in table 1. Distal and proximal extensions of the endophytic system were about equal. Also, the growth rate of infections did not differ noticeably between the summer and winter growing periods.

Staining of the branch sections with phloroglucinol facilitated the judging of infection age. The annual growth rings of the branch and the wedge-shaped sinkers of the parasite imbedded in the xylem tissue of the host were readily observed. The age of young infections was readily determined, but the age of older infections was somewhat difficult to judge, mainly because of discoloration and deterioration of the host wood by stain and canker fungi which invaded the older infections.

A close correlation (correlation coefficient R-924, significant at the 1 percent level) exists between age of infection and extent of swelling.[5/] Table 2 shows the average length of the endophytic system in relation to age of infection. The growth rate of the endophytic system as determined by aging infections and measuring total swelling length in general compared favorably with the growth rate determinations made by taking periodic measurements of the extension of swelling.

5/ Scharpf, Robert F. Growth and extension of the endophytic system of the dwarfmistletoe Arceuthobium campylopodum. MS Thesis, University of California, 43 pp., 1957.

DISCUSSION

As Shea[6] found with dwarfmistletoe on ponderosa pine, the endophytic system of dwarfmistletoe in Digger pine is closely associated with branch swelling. Also, the growth rate of the endophytic system corresponds directly with the vigor of the host as Hawksworth[7] has reported for A. americanum on lodgepole pine and A. vaginatum on ponderosa pine. However, distal and proximal extension of the endophytic system was found to be about equal, whereas Hawksworth states that for A. americanum, A. douglasii, and A. vaginatum the proximal spread of infection was 20-40 percent greater than distal spread. Season of the year, though not showing a marked influence on the growth of the endophytic system of the dwarfmistletoe in Digger pine on Mt. Diablo, may have an influence on the growth of dwarfmistletoes on other hosts growing under different conditions. Results suggest that the growth rate of the endophytic system is more or less constant regardless of the age of infection. The large differences in growth rate of the 8-to 10-year-old infections, as shown in table 2, are probably due to the error in judging accurately the ages of the relatively few older infections.

SUGGESTIONS FOR CONTROL

In conclusion, it may be stated that: (1) individual dwarfmistletoe infections on Digger pine may be eradicated by pruning out the infected branches an inch or more beyond the proximal limits of swelling; (2) internal spread of the parasite proceeds at more or less a constant rate both toward and away from the bole of the tree; therefore branch infections near the host bole must be removed if systemic infection of the main stem of the tree is to be avoided; (3) infections on vigorous branches may be expected to extend more rapidly than infections on branches of poor vigor.

Table 1.--Extension of the endophytic system of dwarfmistletoe in branches of Digger pine

Item	1959		1960	
	Summer	Winter	Summer	Winter
Number of infections	35	35	35	35
Average extension of swelling, in inches				
Distal	.5	.4	.4	.4
Proximal	.5	.4	.4	.4
Total	1.0	.8	.8	.8
Annual average	1.8		1.6	

6/ Shea, op. cit.
7/ Hawksworth, op. cit.

Table 2.--Length of dwarfmistletoe endophytic system on Digger pine, by age of infection

Age (years)	Samples	Average length	Growth rate
	Number	Inches	Inches
1	4	1/ 1.0	1.0
2	17	1/ 1.5	.5
3	25	3.0	1.5
4	37	5.0	2.0
5	39	7.0	2.0
6	9	8.5	1.5
7	11	10.0	1.5
8	8	10.0	.0
9	2	15.0	5.0
10	2	18.0	3.0

1/ These data were obtained from an unpublished study by the author on A. campylopodum. The figures represent the average length of swellings of artificial infections of known age. Infections were produced by placing germinated dwarfmistletoe seeds on potted 4-year-old pines maintained in a lathhouse in Berkeley, California.